Comparison of Navier Stokes and Reduced Navier Stokes unsteady computation in a stenosis.

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Introduction

Navier Stokes solvers are now very accurate to compute flow in stenosed arteries [1]. However, we pretend that asymptotic methods provide a better understanding of the structure of the flow and of the relevant scalings as well [2]. Computational time is very short, so the parameters may be changed easily and their influence can be analysed.

Method

We compare a full 3D Navier Stokes solver (called "comflo") and a set of asymptotic simplified axi symmetrical equations called "RNSP(x)" (Reduced Navier Stokes with no transverse pressure variation). This set is obtained from the Navier Stokes equations noticing that the longitudinal scale is larger than the transversal scale (radius R_0 of the artery) and assuming that the Reynolds number $Re=U_0R_0/\nu$ is large (in practice we will observe that Re must be larger than 50).

The two codes are compared in simplified geometries with rigid walls.
Looking on 2D examples, the parabolicity of the flow is observed: it means that there is a very weak effect of the downstream part of the flow to the upstream. This prediction comes from the RNSP(x) simplification (this is a consequence of the fact that the pressure is constant in every section). The codes are then favourably compared to a simple interacting boundary layer integral code.
The stationary entry effect is then emphasized. Various 3D entry profiles are provided to the NS solver; after a short distance (which is scaled by R_0Re as predicted by the RNSP(x) equations) the flow forgets the details of the entrance boundary conditions and is accelerated in the stenosis. Results are then nearly the same for the two codes.

Next the unsteady responses to a periodic pulsated flow are presented and are favourably compared. The non steady reverse flow after the stenosis is computed as well by the two codes.

Conclusion and perspectives

An alternative method to a complete Navier Stokes resolution has been presented, the results are comparable and involve a much smaller computational time and a better physical understanding. Note that this method may be applied in any internal flow even in turbulent régime, in this case an *ad hoc* closure relation has to be used. This method will allow the study of the numerous geometrical configurations and Reynolds number influence upon separation length

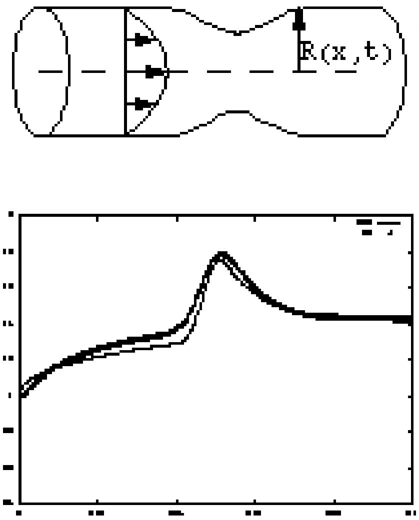

Figure Stenosis geometry and instantaneous longitudinal velocity u(x,r=0,t=4π) along the axis of symmetry of the stenosis: line: RNSP(x), points full NS.

References

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